



WASHINGTON STATE  
DEPARTMENT OF  
**E C O L O G Y**

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**PM<sub>2.5</sub> Sequential Sampler Procedure**

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***Air Quality Program***

**March 1999**

***#99-205***

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**State of Washington  
Department of Ecology  
Air Quality Program**

**PM<sub>2.5</sub> SEQUENTIAL SAMPLER PROCEDURE**

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*March 1999*

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## **1 INTRODUCTION**

This document describes the procedures used to sample PM<sub>2.5</sub> (particulate matter that has an aerodynamic diameter of 2.5 micrometers or less) by the Washington State Department of Ecology Air Quality Program. A Partisol®–Plus Model 2025 Sequential Air Sampler draws a known volume of ambient air at a constant flow rate through a size-selective inlet followed by a WINS Impactor (particle size separator). Particles in the PM<sub>2.5</sub> size range are then collected on a Teflon® filter during a specified 24-hour sampling period. Each sample filter is weighed before and after sampling to determine the net weight (mass) gain of the collected PM<sub>2.5</sub> sample.

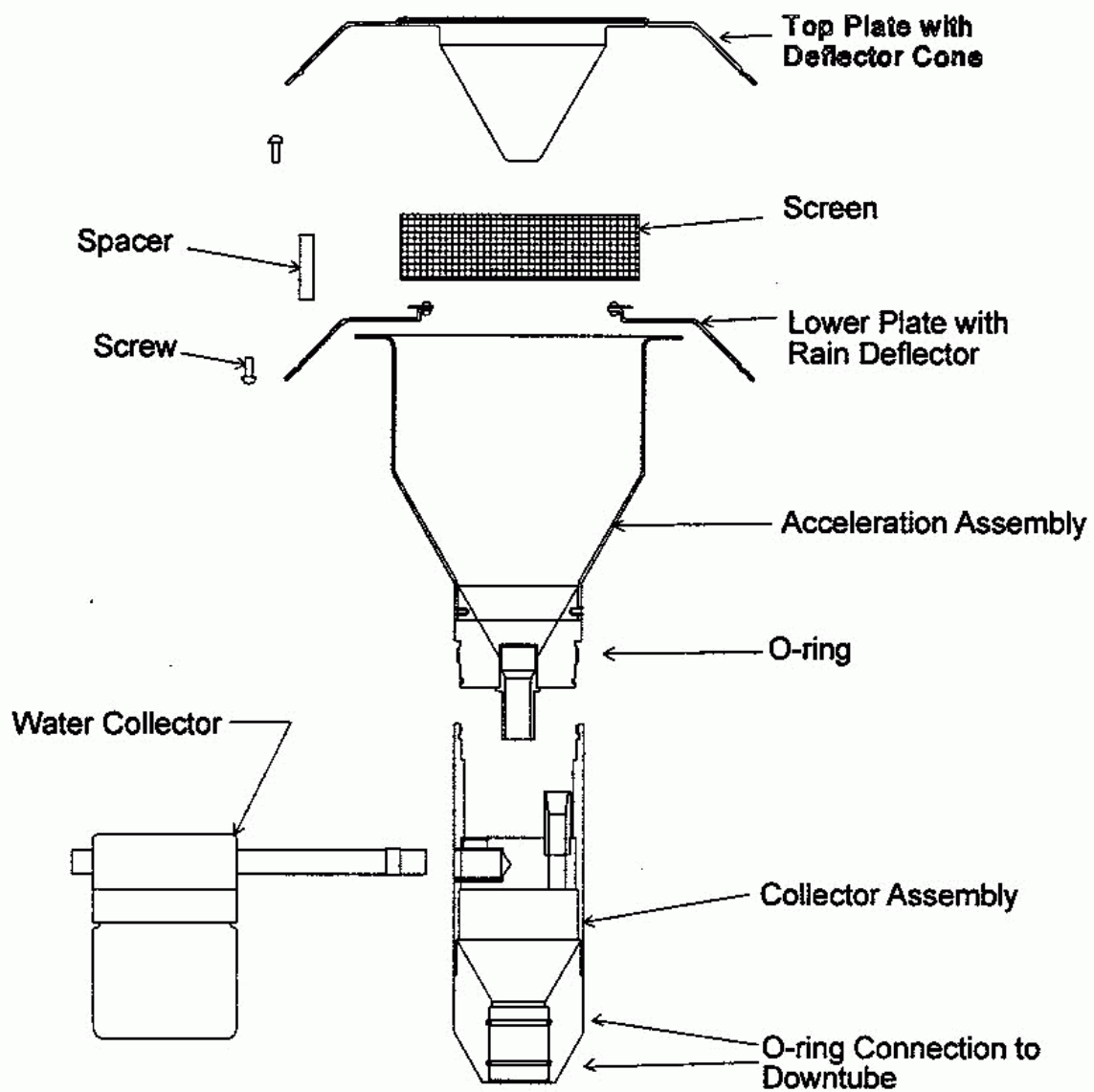
This mass concentration is reported as micrograms per cubic meter at ambient conditions. The reference method for PM<sub>2.5</sub> sampling is given in the Code of Federal Regulations (40 CFR 50, Appendix L).

This document is intended to be used together with the sampler-specific information and instructions provided by the manufacturer of the PM<sub>2.5</sub> sampler in the sampler's operation or instruction manual.

### **1.1 Sampler Inlet And Flow Schematics.**

Figure 1.1 is a schematic drawing showing the inlet head of the PM<sub>2.5</sub> sampler. The inlet is designed to remove particles with aerodynamic diameter greater than 10 µm and to send the remaining smaller particles to the next stage. Figure 1.2 depicts the WINS impactor that removes particles greater than 2.5 µm and allows 2.5 µm in diameter and smaller particles to be collected on a Teflon® filter surface. The design flow rate through the inlet is 16.7 liters per minute.

The Partisol®–Plus Model 2025 Sequential Air Sampler uses a filter cassette magazine that simplifies filter exchange and transport, and minimizes the risk of filter contamination during these procedures. The supply magazine contains pre-weighed filters for sample collection and the storage magazine receives the exposed filters.



**Figure 1-1 Exploded Cross-Sectional View of PM<sub>2.5</sub> Sampler Inlet Head**

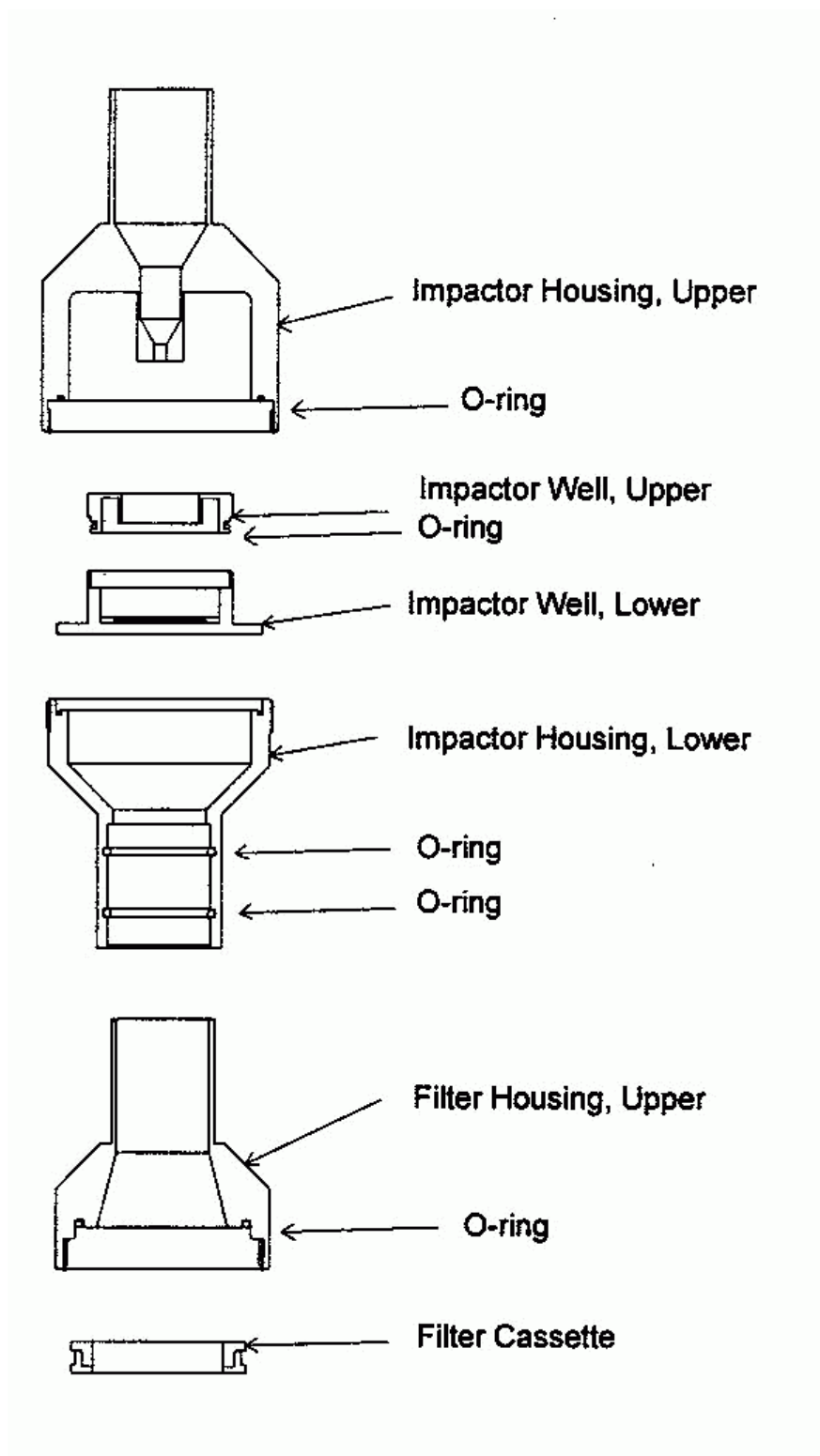


Figure 1-2 Exploded Cross-Sectional View of PM<sub>2.5</sub> Impactor Well and Filter Holder

## **2 EQUIPMENT & SUPPLIES**

- Partisol®–Plus Model 2025 Sequential Air Sampler.
- Additional sampler parts and supplies consisting of WINS impactors, impactor oil, 37mm glass impactor filters, filter cassettes, inlet O-rings, filter magazines.
- 47mm Teflon filters.
- Filter magazine transportation cooler equipped with thermometer.
- Calibration equipment as defined in Section 3.0.
- Laboratory equipment as defined in Section 5.0.
- Miscellaneous hand tools, miscellaneous sampler spare parts including additional gaskets/seals, soft brushes and cotton swabs, calculator, Kimwipes, and worksheets.
- Logbook

## **3 CALIBRATION & VERIFICATION PROCEDURES**

Because PM<sub>2.5</sub> concentration standards are not available for determining calibration relationships, individual components of the sampling method must be calibrated to ensure integrity of reported data.

### **3.1 Discussion Of Flow-Rate Measurement And General Aspects Of The PM<sub>2.5</sub> Sequential Air Sampler Calibration**

This section describes the procedures involved in calibrating the temperature, pressure and flow sensors incorporated in the Partisol-Plus Sampler. U.S. EPA monitoring network requirements for calibration can be found in 2.12 Quality Assurance Handbook, Section 6.

The sampler's mass flow controller operates under the control of the sampler's microprocessor and maintains the sample air stream at a constant volumetric flow rate of 16.67 L/min. through the use of ambient temperature and pressure sensors.

The calibration of the mass flow controller is achieved by calibrating the flow rate with a NIST traceable flow device. The temperature sensor is calibrated with a NIST traceable thermometer while the pressure sensor is calibrated using a barometer traceable to a laboratory grade Fortin mercury barometer.

The time on the data logger will be used to maintain and verify accurate time on the Partisol-Plus samplers.

### **3.2 Basic Calibration Procedure For A Partisol®–Plus Model 2025 Sequential Air Sampler Orifice Device**

#### **3.2.1 Calibration Equipment**

- A transfer standard (bubble meter, orifice) with proper calibration traceable to NIST.
- An associated manometer with a 0 to 10 inch range and minimum scale divisions of 0.1 inches.

- A thermometer capable of accurately measuring temperature over the range of -30 to 50°C (243 to 323°K) to the nearest  $\pm 0.1^\circ\text{C}$  and referenced to an NIST thermometer within  $\pm 0.5^\circ\text{C}$  at least annually.
- A portable, aneroid barometer (e.g., a climber's or engineer's altimeter), capable of accurately measuring ambient barometric pressure within  $\pm 1$  mm Hg resolution and referenced within  $\pm 5$  mm Hg to a barometer referenced to a NIST standard.
- Sampler Calibration Data Sheet, Table 4-2.
- A clean filter

### 3.2.2 Verification Procedures

The following describes the procedures involved in verifying the calibration of the Partisol-Plus Sampler.

**Note:** The procedures vary on whether you start from the **Stop** or **Sampling** modes. It is important that the verification described in this section be performed in the order presented.

Verification or audit of any parameters must be performed when the sampler is in the **Sampling** Mode or **Wait** Mode.

To verify or audit any parameters while in the **Sampling** or **Wait** Modes, follow the procedure below:

- 1) Press Run/Stop.
- 2) Press <F1: Audit>, press any key to continue.
- 3) Press <MENU> twice, Select Audit, Press <Enter>.
- 4) When Audit is complete, press Run/Stop to continue sampling.
- 5) Press <Esc> twice to return to Main Menu Screen.
- 6) Insert a filter cassette containing a new 47mm filter in the top-most position in the filter cassette supply tube.

### 3.2.3 Verifying Ambient Air Temperature

Perform a verification of the ambient air temperature in the **Audit** mode in the following manner:

- 1) Determine the current temperature ( $^\circ\text{C}$ ) at the ambient temperature sensor using an external thermometer by inserting the external thermometer probe into the ambient air temperature radiation shield.
- 2) Verify that the value of Amb T displayed in the Audit Screen is within  $\pm 4^\circ\text{C}$  of the measured temperature. If this is not the case, perform the ambient temperature calibration procedure.

### 3.2.4 Calibration Procedure

The screens that support the user's calibration activities are located in the Service Mode of the Partisol-Plus Sampler. **It is important that the procedures described in this section be performed in the order in which they appear.**

To calibrate any parameter, the sampler must be in **Stop** mode. Follow the procedure below to enter the **Service** Mode from the **Stop** mode.

- 1) Insert a filter cassette containing a new 47 mm filter in the top-most position in the filter cassette supply magazine.
- 2) Press <MENU> to display the Master Menu. Scroll to the Service Menu, press <Enter>.
- 3) Press <F2:Audit> to display the Audit Screen.
- 4) Press <F4:FiltAdv> to move the filter into the sampling position.

Execute the steps below to return to the **Stop Operating Mode** from the **Service Mode**:

- 1) Press <MENU> to display the **Service** Mode.
- 2) Select the “**Exit Service Mode**” option to return to the Stop Operating Mode.

### 3.2.5 Ambient Air Temperature Calibration

Calibration of the Partisol-Plus is done only in the **Stop Operating** Mode.

Perform calibration of the ambient air temperature in the following manner:

- 1) Press <MENU> to enter the Service Menu. With the cursor pointing to “Calibration/Audit,” press <F3:SensCal> to access the Sensor Calibration Screen.
- 2) Loosen the two screws on either side of the temperature probe on the ambient temperature assembly and remove the probe from the radiation shield. The reference and sampler probe should be banded together and immersed to the same depth in an insulated constant temperature bath or block. One of the temperatures measured should be in a ice slurry, another temperature should be at ambient conditions, and the third temperature tested should be in lukewarm water. The reference and sampler probes should be equilibrated for at least 5 minutes at each temperature before the temperature is measured. A series of five measurements should be taken about one minute apart. The average ambient measurement shall be used in the next step.
- 3) Press <Edit> then enter the average ambient reference temperature in °C in the Actual column of the Amb Temp row of the Sensor Calibration Screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input. Write down this offset number in the log book.
- 4) Perform a single point temperature verification to validate the calibration.

- 5) Reinstall the ambient temperature probe in the radiation shield, and tighten the two screws on either side of the probe.

### **3.2.6 Filter Compartment Temperature Calibration**

Perform a single point calibration of the filter compartment temperature in the following manner:

- 1) Press <MENU> to enter the Service Menu. With the cursor pointing to “Calibration/Audit”, press <F4:FiltCal> to enter the Filter Temperature Calibration Screen.
- 2) Using an external thermometer, determine the current temperature at the location of the filter compartment probe in the sampler.
- 3) Press <Edit> and enter the measured filter compartment temperature in °C in the Actual column of the Filt Comp row of the Filter Temperature Calibration Screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input. Write down this offset number in the log book.

### **3.2.7 Verifying Filter Temperature**

Verify the filter temperature in the following manner:

- 1) Insert an empty filter cassette (without filter and support screen) in the top-most position in the filter cassette magazine.
- 2) Press <F4:FiltAdv> to move the empty cassette into the sampling position.
- 3) Open the top section of the sampler and remove the WINS impactor. Insert an external thermometer through the top, positioning it next to the filter temperature probe and determine the current temperature (°C) at the filter temperature sensor, using an external thermometer.
- 4) Verify that the value of Filt Temp displayed in the Audit Screen is within  $\pm 4$  °C of the measured temperature. If this is not the case, perform the filter temperature calibration procedure.
- 5) Remove the external temperature thermometer and reinstall the WINS impactor and close the top section. Perform an external leak check to ensure that WINS impactor is reinstalled properly and that there are no leaks.

### **3.2.8 Filter Temperature Calibration**

Perform filter temperature calibration in the following manner:

- 1) Press <MENU> to enter the Service Menu. With the cursor pointing to “Calibration/Audit”, press <F4:FiltCal> to enter the Filter Temperature Calibration Screen.
- 2) Remove both sampling magazines from the sampler. Loosen the two screws (in some cases three screws) on the either side of the filter temperature probe in the sampling

- platform of the filter compartment and remove the temperature probe from the sampling platform.
- 3) Note the depth and location of the filter temperature probe in the sampling platform of the ventilated filter compartment.
  - 4) The reference thermometer and sampler probe should be banded together and immersed to the same depth in an insulated constant temperature bath or block. One of the temperatures measured should be an ice slurry, another should be at ambient conditions and the third temperature should be in lukewarm water. Reference and sampler probes should be equilibrated for at least 5 minutes before the temperature is measured. A series of five measurements shall be made at approximately one minute intervals. The average ambient temperature shall be used for the next step.
  - 5) Press <Edit> and enter the measured filter temperature in °C in the Actual column of the Filter row of the Filter Temperature Calibration Screen and press <Enter>. The sampler automatically adjusts the corresponding offset based upon this input. Write down this offset number in the log book.
  - 6) Reinstall the filter temperature probe into the sampling platform to the depth marked in step 2 above. Tighten the two screws to hold probe at the correct depth.
  - 7) Perform a single point temperature verification to validate the calibration.

### **3.2.9 Verifying Ambient Pressure**

Verify the ambient pressure in the following manner:

- 1) Determine the current ambient pressure in mm Hg
- 2) Verify that the value for AmbPres in the Audit Screen is within  $\pm 10$  mm Hg of the measured ambient pressure. If this is not the case, perform the ambient pressure calibration procedure.

### **3.2.10 Ambient Pressure Calibration**

Perform ambient pressure calibration in the following manner:

- 1) Press <MENU> to enter the Service Menu. With the cursor pointing to “Calibration/Audit” press <F3: SensCal> to enter the Sensor Calibration Screen.
- 2) Determine the current ambient pressure in mm Hg.
- 3) Press <Edit> enter the measured ambient pressure in the Actual column of the Amb Pres row of the Sensor Calibration Screen, press <Enter>. The sampler automatically adjusts the corresponding offset, write down this offset number in the log book.

### **3.2.11 Flow Verification**

Flow verification must be done before disturbing any seals. Perform the flow verification procedure below in the following manner:

- 1) Insert a filter cassette containing a new 47mm filter in the top-most position of the filter cassette supply magazine.
- 2) Press <Menu> to display the Master Menu.
- 3) Press <F1:LeakChk> to display the Leak Check screen.
- 4) Press <F4:FiltAdv> to advance the filter and place the filter from the magazine into the sample position. Wait for filter change to complete.
- 5) If you are using the Streamline FTS Flow Transfer Standard to verify the flow of the Partisol-Plus Sampler, confirm that the FTS calibration constants *m* and *b* are entered in the Audit Screen.
- 6) Remove the sample inlet from the external sample tube of the Partisol-Plus Sampler.
- 7) Attach the Streamline FTS Flow Transfer Standard to the sample tube. Other flow meters may require the use of the Flow Audit Adapter which should be installed with its valve **open**.
- 8) Press <F2: Start>. After the prompt then press <F3: Valve>.
- 9) Select Set Flow in the Audit screen and press <Edit>.
- 10) It is recommended that the set point be the regular operational flow, which is usually 16.7 l/minute. Ensure that the flow rate, as displayed in the Cur (current) column stabilizes close to the entered set point ( $\pm 4\%$ ). If not, perform the flow calibration procedures.
- 11) If using the FTS Streamline Flow Transfer Standard to measure flow, press <Edit>, then enter the measured FTS Pressure (in H<sub>2</sub>O) in the FTS Pres column. The Partisol-Plus will calculate the flow and display the result in the FTS Flow field (l/minute). If using another flow measurement device, determine the measured flow rate in l/minute. Compare the measured flow with the current flow displayed in the Audit Screen.
- 12) Verify that the current flow is within  $\pm 4\%$  of the measured flow. If this is not the case, perform the flow calibration procedure.
- 13) If the verification procedure is complete, reinstall the First Stage Inlet.

### **3.2.12 External Leak Check**

Perform a system leak check in the manner described below. In addition to the required leak checks, a leak check must also be performed anytime when a seal in the sampler is disturbed.

**NOTE:** To ensure there are no leaks, a filter cassette containing a new 47 mm filter must be installed in the sampling position of the sampler.

If a filter change was not done in the first step of the verification procedure, follow steps 1-4 below to move a filter into the sampling position.

**NOTE:** If the Leak Checks or Flow Verification are being performed while the sampler is in the **Sampling Mode**, remove the storage magazine which may contain previously sampled filters and replace it with a clean storage magazine before advancing the partially sampled filter to the storage magazine. Carefully remove the sampling filter cassette from the storage magazine after step 3 below and reinstall it in the topmost position of the supply magazine so that this filter will be moved back into the sampling position to complete the sampling run after the verification or maintenance is complete. The sampler will begin the sampling run again after the sampling cassette is in the correct position.

- 1) Insert a filter cassette containing a new 47 mm filter in the topmost position of the filter cassette supply tube.
- 2) Scroll to LeakChk then press <ENTER> to display the Leak Check screen. Press <F4:FiltAdv>. Wait for filter change to complete.
- 3) Remove the sample inlet from the external sample tube.
- 4) Install the flow audit adapter on the end of the tube.
- 5) Close the valve on the flow audit adapter.
- 6) Press <F2: Start>. After the prompt, press <F1: Externl> to select the external leak check.
- 7) Follow instructions displayed on screen.
- 8) The sampler will automatically pull vacuum and check for flow.
- 9) A pass or a fail message will be displayed at the end of the leak check cycle. A pressure drop of 25mm Hg/min or less is the sampler's leak check pass criteria.
- 10) If a leak check fail message is displayed on the screen, insert a new filter cassette containing a new 47mm filter in the topmost position of the filter cassette supply tube and repeat the leak check procedure.
- 11) If the leak check fails again, attempt to find the leak and repair. If unsuccessful to locate the source of leak, contact the Calibration and Repair Unit at the Dept. of Ecology.
- 12) If the leak check passes, slowly open the valve on the flow audit adapter.
- 13) If performing a flow verification immediately, retain the filter cassette with 47 mm filter in the sampling position.
- 14) Otherwise, remove the flow audit adapter from the external sample tube and reinstall the sample inlet previously removed.

### **3.2.13 Internal Leak Check**

Perform an internal leak test of the Partisol-Plus Sampler in the manner described below.

**NOTE:** To ensure that there are no leaks a filter cassette containing a 47mm Leak Check metal disk must be installed in the hardware.

- 1) Insert a filter cassette containing a leak check disk (the screen should be removed before installing the leak check disk) in the topmost position of the filter cassette supply tube. Insert the supply magazine into the sampler.
- 2) In the Leak Check Screen, press <F4: FiltAdv> to move the leak check cassette into the sampling position. Wait for filter change to complete.
- 3) Remove the sample inlet from the external sample tube.
- 4) Press <F2: Start>. Press <F2: Internl> to select the internal leak check. Follow instructions in the display to complete the leak check.
- 5) The Partisol-Plus sampler will run an automatic leak check, and report either a pass or fail message. A pressure drop of 140 mmHg/min or less is the sampler's leak check pass criteria.
- 6) Press <F4: FiltAdv> to move the leak check cassette to the storage magazine.
- 7) If a failure message has displayed, clean the cassette and leak check disk carefully. Examine the cassette and disk for any external nicks or scratches. Discard any damaged cassette or disks, and re-run the test with a clean, undamaged cassette and leak check disk.
- 8) If leak check fails after again attempt to find leak and repair. If unsuccessful to locate the source of leak, contact the Calibration and Repair unit with Dept. of Ecology.
- 9) If a pass message is displayed replace the 1st stage inlet.

**NOTE:** If the verification is being performed while the sampler is in the Sampling Mode ensure that the partially sampled filter is reinstalled in the topmost position of the supply magazine, so that the sampling run will be completed on the correct sampling filter.

### **3.2.14 Flow Calibration**

Perform the temperature calibration, pressure calibration and leak check described above before executing the flow calibration procedure below.

Calibrate the flow in the following manner:

**NOTE:** Ensure that the filter cassette previously installed in the sampler to perform the above leak check remains in the unit for the flow verification.

- 1) If you are using the Streamline FTS Flow Transfer Standard to verify the flow of the Partisol-Plus Sampler, confirm that the FTS calibration constants m and b are entered in the Audit Screen.
- 2) Remove the sample inlet from the external sample tube of the Partisol-Plus Sampler.

- 3) Attach the Streamline FTS Flow Transfer Standard to the sample tube. Other flow meters may require the use of the Flow Audit Adapter which should be installed with its valve **open**.
- 4) Press <Edit> and enter the desired minimum and maximum calibration flow rates (Min. Flow and Max. Flow). It is recommended to use 15.0 l/minute for Min Flow and 18.4 l/minute for Max Flow. These values are 10% below and 10% above 16.7 l/min respectively.
- 5) For Num Points: enter 3 for three calibration points.
- 6) Press <F9: Start> to initiate the flow calibration.
- 7) Wait for the flow to stabilize, then press <Edit> and enter either the pressure drop (inches H<sub>2</sub>O) from the Streamline FTS in the “Pressure” field or the flow (l/minute) from a flow meter in the “Act Flow” field. Then press <Enter>.
- 8) The sampler automatically adjusts the Offset and Span values in the Flow Calibration Screen once it performs measurements at all flow rate plateaus.

### 3.3 Sampler Calibration Frequency

To ensure accurate measurement of the PM<sub>2.5</sub> concentrations, calibrate PM<sub>2.5</sub> samplers upon receipt. Table 3.1, Table 3.2 and Table 3.3 below summarize the calibration, verification and maintenance frequencies. Table 3.2 and 3.3 are to be used for quality control purpose and kept on site.

**Table 3-1 Calibration And Verification Check Intervals**

Parameter	Recommended interval
Single point flow rate verification	Every 4 weeks
Flow rate multi-point verification	On installation, then annually or when one point failure
Flow rate Calibration	If multi-point verification failure
Temperature verification (single point: ambient air inlet sensor and filter temperature sensor)	Every 4 Weeks
Temperature multi point calibration	On installation, then annually
Temperature Calibration (Multi point)	If multi-point verification failure
Pressure verification	Every 4 weeks
Pressure calibration	On installation, then annually or if out of specs.

The sampler also needs to be calibrated after any electro-mechanical repairs that might affect sampler calibration and if the sampler is transported.

**Table 3-2 PM<sub>2.5</sub> Sampler Annual Performance And Maintenance Check Sheet**

	Frequency	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Acceptance Criteria
One Point Flow Rate Verification	1/4 Weeks													± 4% of the Transfer Standard
Flow Rate multi-point Verification	1/Year Or if One Point Failure													± 4% of the Transfer Standard
Flow Rate Calibration	If Multi-Point Failure													± 4% of the Transfer Standard
Temperature Multi-point Verification	1/Year													± 2°C of Standard
Temperature Calibration	If Multi-Point Failure													± 2°C of Standard
Pressure Verification	1/4 Weeks													± 10 mm Hg.
Pressure Calibration	1/Year													± 10 mm Hg.
Clock/timer Verification	1/4 Weeks													1 min/month
Disassemble, Inspect and Clean Sample Inlet	1/4 Weeks													
Clean Interior of Sample Case	1/4 Weeks													

**Table 3-3 PM<sub>2.5</sub> Sampler Quarterly Performance And Maintenance Check Sheet**

Parameter	Frequency	Initial and date boxes after each check is completed																		Nominal Value
External Leak Check	Every 5 Sampling Events																			80 ml/min
Internal Leak Check	Annually & after major maintenance																			80 ml/min
One-point Temperature Verification	1/4 Weeks																			± 4°C of Standard
Water Collector Bottle Inspection	Every 5 Sampling Events																			
Impactor Well Cleaning and Oiling	Every 5 Sampling Events																			

## **4 FIELD OPERATIONS**

This section presents information pertinent to the routine operation of a PM<sub>2.5</sub> monitoring site. It covers an array of topics, ranging from initial site selection to final data documentation.

### **4.1 Siting Requirements**

#### **4.1.1 Probe Height**

##### *4.1.1.1 Microscale*

The sampler inlet for microscale PM<sub>2.5</sub> monitors must be 2-7 meters above ground level.

##### *4.1.1.2 Middle or larger scale*

The required height of the air intake for middle or larger scales is 2-15 meters.

#### **4.1.2 Horizontal Spacing for Obstructions**

##### *4.1.2.1 Microscale*

- A minimum of 2 meters separation from walls, parapets, penthouses etc. No furnaces or flues should be nearby.
- The sampler must be at least 10 meters from the dripline of trees and if possible it is recommended that the sampler be placed 20 meters from the dripline.
- The sampler must be located away from obstacles such as buildings and trees that act as an obstruction, so that the horizontal distance between the obstacles and the sampler is at least twice the height that the obstacle protrudes above the sampler. For example, if the obstacle protrudes 15 meters above the sampler then the distance between the obstacle and the sampler must be at least 30 meters.
- There must be an unrestricted airflow in an arc of at least 270-degree around the sampler except for street canyon sites.

##### *4.1.2.2 Middle or larger scale*

Stations not meeting these criteria may be classified as **micro** or **middle** scale.

#### **4.1.3 Spacing from Roads**

**4.1.3.1 Microscale:** For microscale station, the sampler must be between 5 and 15 meters from the major roadway. For a street canyon site the location must be between 2 and 10 meters from the roadway.

**4.1.3.2 Middle scale and Neighborhood scale:** Figure 4.1 provides guidance on the recommended monitoring distances from the paved roads with different levels of average daily traffic.

#### **4.1.4 *Spacing from nearby sources and other Considerations***

- Stations should not be located in an unpaved area unless there is vegetative ground cover year-round.
- In case of emissions from a chimney resulting from natural gas combustion, the sampler should be placed at least 5 meters from the chimney.
- Monitors should not be located within 100 meters of residential wood burning appliances.

#### **4.1.5 *Other Requirements***

Table 4-1 presents basic siting criteria for the placement of the PM<sub>2.5</sub> sampler. This is not a complete listing of siting requirements. Instead, it should be used as an outline to determine a sampler's optimum location. Complete siting criteria are presented in 40 CFR 58, Appendix E.

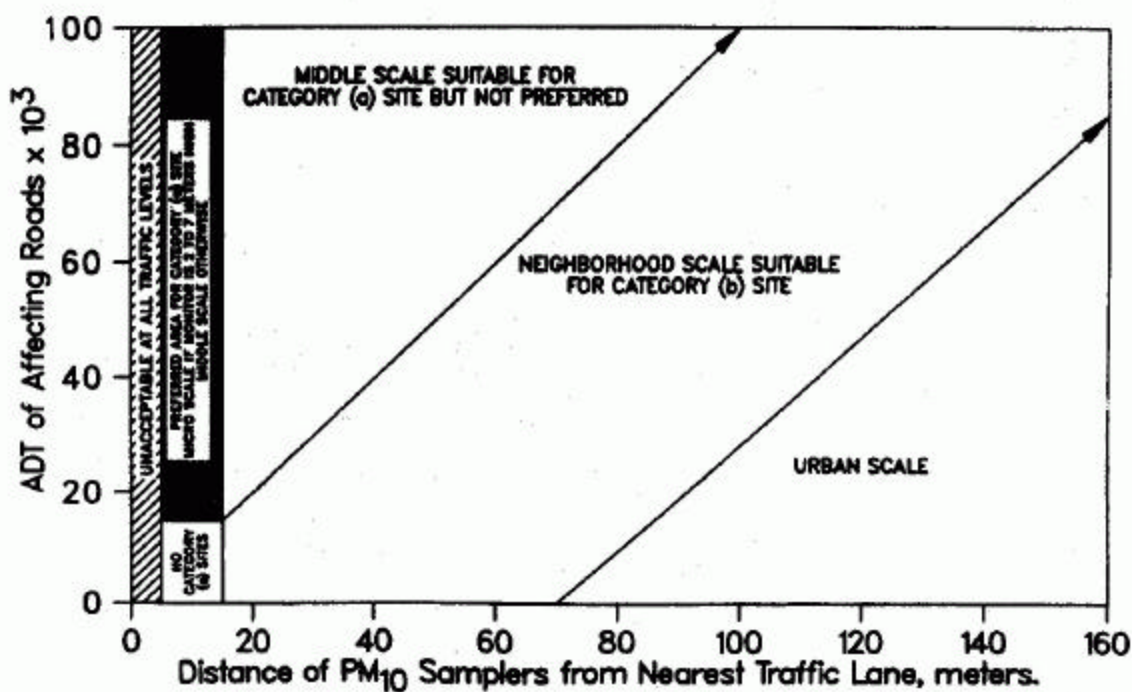
Several additional factors must also be considered in determining where the sampler will be deployed. These include accessibility under all weather conditions, availability of adequate and stable power, and security of the monitoring personnel and equipment. The site should be able to provide sufficient power for the primary sampler, a collocated sampler and an FRM performance evaluation sampler.

The sampler must be situated where the operator can reach it safely despite adverse weather conditions. If the sampler is located on a rooftop, care should be taken that the operator's personal safety is not jeopardized by a slippery roof surface during inclement weather. Consideration also should be given to the fact that routine operation (i.e., calibrations, filter installation and recovery, flow checks, and audits) involves transporting supplies and equipment to and from the monitoring site.

The security of the sampler itself depends mostly on its location. Rooftop sites with locked access and ground-level sites with fences are common. The security of the operating personnel, as well as that of the sampler must always be considered.

**Table 4-1 Minimum PM<sub>2.5</sub> Sampler Siting Criteria**

Scale	Height Above Ground (Meters)	Vertical and Horizontal Distance from supporting structure (Meters)	Other Spacing Criteria
Micro	2 to 7	>2	Should be >20 meters from trees.
Middle, neighborhood, urban, and regional scale.	2 to 15	>2	Distance from sampler to obstacle, such as buildings, must be twice the height that the obstacle protrudes above the sampler.
			Must have unrestricted airflow 270 degrees around the sampler inlet.
			Sampler is maintained in a horizontal plane and is 2.0+/-0.2 meters above the floor or horizontal surface.
			Sampler inlet is at least 2 m but not greater than 4 m from any collocated PM <sub>10</sub> sampler. (See 40 CFR 58, Appendix A.)



**Figure 4-1 Acceptable areas for Micro, Middle, Neighborhood and urban samplers except for micro scale street canyon sites**

## **4.2 Sampler Installation**

- 1) On receipt of a PM<sub>2.5</sub> sampler, visually inspect it to ensure that all components are accounted for. Notify the laboratory immediately of any missing or damaged equipment.
- 2) Carefully transport the sampler to the field site. Secure the PM<sub>2.5</sub> sampler in its location keeping it level.
- 3) Install the sampler inlet on the base unit and check all tubing and power cords for crimps, cracks or breaks
- 4) Turn on the sampler and perform a leak test with a filter in the filter cassette.
- 5) Allow the sampler to run and equilibrate with ambient conditions for about 15 minutes and calibrate the sampler as discussed in the section on Calibration Procedures.
- 6) Fill out the initial calibration form.

## **4.3 Sampling Operations**

This section discusses the steps to take to prepare for and to complete a sampler run.

- 1) Fill out top portion of run data sheet with information related to the sample collection such as site location or identification number, date and time of sampler setup visit, sample start date, filter identification and cassette ID number. The run data sheet is shown in Table 4-3 and the operator will receive it with the filter magazine and this will be the chain of custody sheet. The number of run data sheets will correspond to the number of filters in the magazine.
- 2) Ensure that the sampler is not operating and that there is enough time available to complete setup procedures before its automatic start.
- 3) Open the filter holder assembly and install the filter magazine containing pre-weighed filters. Do not remove the filters from the cassettes. Install the filter cassette magazine into the sampler on the left side and a clean magazine on the right side.
- 4) In Main screen Press <F3: FiltSet> and then press <F4: FiltLst> to display the filter list.
- 5) Press EDIT, then enter the filter ID #'s and press ENTER.
- 6) Press the < → > arrow to move the cursor to the cassette ID#'s field and Press EDIT, then enter in the cassette ID# in this field and Press ENTER.
- 7) The chain of custody sheet from the lab will tell the operator of the sequence in which the filters are stored in the magazine. The operator must make sure that filter ID#'s are entered in the same order as they are stored in the filter magazine.
- 8) If the filter cassette magazine has a blank filter, then after entering the filter ID# and cassette ID #, press the side arrow key < → > to move the cursor on the screen to Blank field and pressing F1< -List> or F2 <+List> will let the operator select YES or NO options to denote if the filter is a blank or not.

- 9) To program the sampler for midnight to midnight continuous sampling:
- 10) The sampler must be in a STOP mode to enter a sampling program
- 11) Press ESC twice to get to MAIN MENU. Press <F5: SETUP>.
- 12) Press EDIT to set up Default Sample Repeat Time. For Samplers running 1/1 enter 24:00 and press ENTER. For samplers running on 1/3 schedule enter 72:00 and press ENTER. For collocated samplers running on 1/6 schedule enter 144:00 and press ENTER.
- 13) The sampler is now ready to sample. Inspect the records of the sampler and the Sampler Annual Performance, Quarterly performance and Maintenance Check Sheet in Tables 3.1, 3.2, 3.3 and 7.1. Perform the scheduled maintenance, verification and calibration activities.
- 14) If it is time for the every 4 weeks check, measure and record independent measurements of ambient temperature and pressure, and ensure that the ambient inlet temperature and pressure readings taken by the sampler are within 4.0 °C and 10 mm Hg of the independent readings. Also check the sampler's display for the filter temperature and ensure this value is within 5 °C as compared to the ambient temperature display. Keep a record of the activities performed in the logbook.

#### **4.4 Post Sampling**

- 1) Return to the monitoring site within 96 hours (4 days) of the end of the sample collection period and carefully remove the filter magazine from the sampler. Place the cover on the filter magazine.
- 2) Place the filter cassette magazine in a protective covering (polyethene bag) such that the cover does not come off. Cover the magazine with blue ice and place it in the cooler box. After retrieval from the sample care must be taken to maintain the filter magazine as cool as possible in an ice-box and protect it from exposure to temperatures above 4 °C.
- 3) Check the sampling run status on the Main Screen and note if the status is other than OK. Press <F4:Data> to view the filter data from the run. Record the Total sample Time, Sampler Volume, Sample removal date/time, Sampler's indicated ambient temperature and barometric pressure, final flow rate, average flow rate, coefficient of variation of the flow rate, on the Sampler Run Data Sheet. If the status codes is other than OK, then verify the validity of the run by pressing <F3:More Dat>, until the filter Data Status Codes Screen appear.
- 4) Also record, if the flow rate, filter temperature or elapsed sample time were out of spec and if any flags triggered by the sampler. Record unusual conditions that may have affected the sample.
- 5) Install a loaded supply magazine and empty storage magazine and repeat steps 1 through 9 for next sampling run.
- 6) Record any comments or unusual conditions such as sampler tampering or malfunctions, construction activities, fires or dust storms on the form.
- 7) Transport the filter magazine and store it in the refrigerator/freezer. Ship the filter magazine and the Sampler Run Data Sheet(s), in protective bag with the filter magazine, to the lab. The mailing should be done as soon as possible Monday, Tuesday, or Wednesday, using Federal Express Priority Overnight.

#### 4.5 QC Flow-Check Procedure

A flow rate verification check of the sampler flow rate is required every four weeks. The Sampler QC Check Data Sheet provided in Table 4.3 should be maintained. These check data will provide an indication of when flow limits of  $\pm 4\%$  have been exceeded. The procedure for flow-rate verification check is described in Section 3.

Deviation of 5% or greater from the design value in flow rate during sampling require that the sample data be flagged for potential invalidation.

Changes in flow rate calibration of more than 4 percent as determined by a monthly field flow rate verification check may cause invalidation of all samples collected since the last acceptable flow rate check.

- 1) Record the **actual** flow rate measured by the flow verification check device and the flow rate **indicated** by the sampler.
- 2) Using the above information, calculate the percentage difference as:

$$\text{QC \% Difference} = \left[ \frac{\text{Ind} - \text{Act}}{\text{Act}} \right] \times 100$$

- 3) If the sampler flow rate is within 96 to 104 percent of the measured flow rate at actual conditions and if the sampler flow rate is within 95 to 105 percent of the design flow rate of 16.67 L/min, the sampler is operating properly.
- 4) If either limit is exceeded, repeat leak check procedure, as described in Section 3. Investigate and correct any malfunction and recheck the flow. If necessary, recalibrate before sampling again.

**Table 4-2 Initial Calibration Form**

**Partisol-Plus Model 2025 Sequential Air Sampler Calibration Sheet**

Sampler Serial Number	Impactor Serial Number
2025A2 _____	200FA4 _____

**Instrument Calibration Constant Values:**

Screen	Assignment	Offset	Span
Sensor Calibration	Amb Temp:		
	Amb Pres:		
Filter Temp Calibration	Filter:		
Filter Compartment Calibration	Filter Comp:		
Flow Calibration	Flow Calib:		

Software Version: \_\_\_\_\_  
Signature \_\_\_\_\_

Software Update \_\_\_\_\_  
Date \_\_\_\_\_

**Table 4-3 PM<sub>2.5</sub> Sampler Run Data Sheet**

AIRS Number			
Station Name		Filter ID Number	
Station Location			
Sampler Serial #			
Sample Date		Cassette ID Number	
Sample Removal (Date/Time)		Sample Ship Date (Date/Time)	
Operator		Operators Initials	
Ambient temp.	°C	Ambient press.	Mm Hg
Start Time		Start Date	
Stop Time		Stop Date	
Total Sample Time			
Sampled Volume	m <sup>3</sup>	Flow Rate, CV	%
Status Codes			
Average Flow Rate	l/minute		
Min. Ambient temp.	°C	Min Ambient press.	Mm Hg
Avg. Ambient temp.	°C	Avg. Ambient press.	Mm Hg
Max Ambient temp.	°C	Max Ambient press	Mm Hg
<b>Comments by instrument operator</b> (Unusual conditions, weather etc.)			
Area below for lab use only			
Sample temp. upon receipt	°C	Sample Receipt Date	
		Time	
Gross Weight ( <i>M<sub>f</sub></i> )	mg	Calculated Concentration	mg/m <sup>3</sup>
Tare Weight ( <i>M<sub>i</sub></i> )	mg		
$\frac{\text{mg}}{\text{m}^3} = \frac{(M_f - M_i)}{\text{Total Volume}} \times 10^3$			
<b>Comments by laboratory analyst</b>			

**Table 4-4 PM<sub>2.5</sub> Sampler QC Check Data Sheet**

Station # _____	Date: _____
Location: _____	Time: _____
Sampler # _____	Operator: _____
Thermometer Serial # _____	
	• Certification Date: _____
Barometer Serial # _____	
	• Certification Date _____
Flow Standard Serial # _____	
	• Certification Date: _____

**QC Check**

**Temperature Check**

Ambient

Actual	_____ °C	Indicated	_____ °C	Difference	_____ °C
Filter					
Actual	_____ °C	Indicated	_____ °C	Difference	_____ °C

**Pressure Check**

Actual	_____ mm Hg	Indicated	_____ mm Hg	Difference	_____ mm Hg
--------	-------------	-----------	-------------	------------	-------------

**Flow Check**

Actual	_____ L/min	Indicated	_____ L/min	% Difference	_____ %
--------	-------------	-----------	-------------	--------------	---------

**Leak Check**

External Leak Check				Internal Leak Check			
Pass <input type="checkbox"/>	mm. Hg	Fail <input type="checkbox"/>	mm. Hg	Pass <input type="checkbox"/>	mm. Hg	Fail <input type="checkbox"/>	mm. Hg
	_____		_____		_____		_____

---


$$\text{QC \% Difference} = \left[ \frac{Ind - Act}{Act} \right] \times 100$$

## **5 LABORATORY ACTIVITIES**

Precision, accuracy, and calibration procedures for the laboratory apparatus along with filter preparation and analysis are described in this section.

The microbalance will be located away from potential sources of drafts such as doors, windows, aisles with frequent traffic, ventilation ducts and equipment with fans.

47mm Teflon filters meeting the requirements specified in 40 CFR 50, Appendix L are used in the collection of PM<sub>2.5</sub>.

### **5.1 Equipment And Supplies**

- 1) Mettler MT5 Microbalance.
- 2) Smooth non metal forceps for filter handling
- 3) Petri slide dishes
- 4) Petri dishes (Optional)
- 5) Primary weight standards (NIST traceable weights with forceps)
- 6) Working weight standards
- 7) Static Deionizer
- 8) Cassette rings
- 9) Magazines

### **5.2 Filter Procedures**

#### **5.2.1 Filter Handling**

47mm Teflon filters meeting the requirements specified in 40 CFR 50, Appendix L are used in the collection of PM<sub>2.5</sub>.

- New filters will be placed in the conditioning environment upon arrival and stored there until the pre-sampling weighing. The filters will be handled using smooth nonmetal forceps.
- Do not fold or crease clean filters prior to weighing or use.
- Place filters in petri dish in a controlled humidity/temperature room or conditioning chamber to equilibrate for at least 24 hours before weighing. Relative humidity (RH) must be held constant with a mean value between 30 and 40%, with a variability of not more than  $\pm 5\%$ .
- Temperature must be held constant with a mean value between 20 and 23°C, with a variability of not more than  $\pm 2^\circ\text{C}$ . RH and temperature must be checked and recorded on equilibration days (either manually or by a hygrothermograph) to assure compliance with these guidelines.

- Record equilibration chamber malfunctions, discrepancies, and maintenance activities in the laboratory log book or database.

### **5.2.2 Visual Filter Inspection**

Visually inspect filters for the following defects before their initial weighing. Defective filters must be rejected and returned to the manufacturer. Those defects include:

- **Pinhole** - A small hole appearing as a distinct and obvious bright point of light when examined over a light table or screen, or as a dark spot when viewed over a black surface.
- **Loose material** – If there is any loose material or dirt particles on the filter then the filter must be discarded.
- **Discoloration** - Any obvious visible discoloration that might be evidence of a contaminant.
- **Non-uniformity** - Any obvious visible non-uniformity in the appearance of the filter when viewed over a light table or black surface that might indicate gradations in porosity across the face of the filter.
- **Other** - A filter with any imperfection not described above, such as irregular surfaces or other results of poor workmanship.

### **5.2.3 Filter Conditioning Procedure**

Filters must be conditioned prior to weighing. The lab is temperature and humidity controlled, with temperature maintained at 20 - 23 °C  $\pm$ 2 °C and humidity maintained at 30 – 40% RH  $\pm$ 5%.

- Petri dishes containing filters are left open for at least a 24-hour conditioning time period.
- A unique filter identification number will be assigned to each filter. The first two digits represent the year and the next two digits denote the week in which the filter is tare weighed. For example: A filter number 9912XXXX signifies that the filter was tare weighed in the 12<sup>th</sup> week of the year 1999.
- Record the filter identification numbers of the filters being conditioned into the Filter Conditioning Log book or database. Record the date and time.
- After 24 hours record the end date and time. Record the minimum, maximum and average (mean) humidity and temperature readings for the 24-hour time period.

### **5.2.4 Initial Weighing Procedures (Tare Weight)**

Filters must be weighed on an analytical balance with a minimum resolution of 0.001 mg (1  $\mu$ g) and a repeatability of 1 $\mu$ g. Each balance must be identified by a balance number and calibrated annually.

All QC data should be recorded on the Internal Quality Control Log Sheet (Figure 5.1), a laboratory log book or database encompassing all elements of the Internal Quality Control Log Sheet.

- 1) Zero the balance according to manufacturer's directions.
- 2) Perform a QC "Standard Weight" check on the analytical balance. Two sets of Class 1 mass reference standards (100 mg and 200 mg), traceable to National Institute of Standards and Technology, will be used for microbalance verification. One set, the "Primary Standards", will be re-certified annually; the second set, the "Working Standards", will be used during routine operations, checked quarterly against the Primary Standards, and re-calibrated as necessary. Following verification of the microbalance using

the Primary Standards to within tolerances of  $\pm 3\mu\text{g}$ , weigh each Working Standard 7 times. The difference between each set of values must be  $\pm 3\mu\text{g}$ ; a mean value will then be determined to be the “true” value and all subsequent weighing must be within  $\pm 3\mu\text{g}$  of the true weight.

- 3) Using a smooth nonmetal forceps select a conditioned filter. Place the filter over the  $^{210}\text{Po}$  deionizing unit for 30-60 seconds to reduce static electricity. Be careful not to bump the filter against the chamber opening. Place the filter in centered on the weighing pan to avoid corner load errors.
- 4) Allow the microbalance to stabilize. Once the stability detector goes off, record the pre-sampling weight with the filter identification number in the Weight Log book or a computer database. Each filter will be weighed at least twice until the weights agree within  $15\mu\text{g}$ ; if not, troubleshooting and reweighing are in order.
- 5) Carefully return the filter to the appropriate Petrislide dish with the filter ID Barcode on the petri slide dish.
- 6) For the filters to be used at the sites, each filter will be installed in a filter cassette, marked with an assigned number and put in the filter magazine. The filters can be delivered / picked up by a field operator with the Field data sheet /Chain of Custody form. This form will have a bar-code indicating the filter identification number.
- 7) The pre-sampling (tare) weighing shall be within 30 days of the sampling period.

**NOTE:** Filters have been tare weighed in numerical sequence, with lower numbers first. Operators will use the filters in the correct numerical sequence, thereby maintaining relative consistency in time between tare and final weights for all filters. Operators will use the filter magazine with an earlier week number prior to the filter magazine with a later week number on it. For example: Use the magazine with the number 99113705 (tared in 11<sup>th</sup> week) before 99133701 (tared in 13<sup>th</sup> week)

### ***5.2.5 Quality Control Checks During Weighing***

During the filter weighing process, the following QC checks are recommended.

#### ***5.2.5.1 Laboratory Temperature and Humidity Checks***

Prior to each weighing session record that the previous 24-hour mean and peak temperature and humidity values meet specifications (see section 5.1). After every 10 filters are weighed the lab conditions will be checked. If the lab conditions vary beyond the acceptance criteria for temperature or humidity a Corrective Action Report form must be completed. All the filters will be reweighed once the specified lab conditions have been re-established.

All pre-sampling filters will be weighed twice. At the end of a 10 post sampling filter weighing session, one of the filters must be selected to be reweighed. Weight should be within  $10\mu\text{g}$  of the original weight; if not, troubleshooting and reweighing are in order.

#### ***5.2.5.2 Lot Blanks, Laboratory Blanks and Field Blanks***

Three types of filter blanks are used for QC checks:

- Lot blanks are used to determine filter weight stability over a long period of time. Three unsampled filters from each new filter lot will be lot blanks. After an initial 24- hour conditioning, these three lot blanks will be reweighed periodically. These measurements will be recorded in a QC notebook or database. The weightings will continue until the 24-hour weight change is less than 15 µg. This will determine the pre-conditioning period for that entire lot.
- Lab blanks go through the same processes as regular filters. The filters are pre-conditioned, weighed, refrigerated, post-conditioned and reweighed. Lab blanks do not leave the lab environment. If the weight change exceeds 15 µg, it indicates contamination in the conditioning chamber. Corrective actions will be performed to prevent this contamination from re-occurring.
- Field blanks are sent with regular filters to the field and go through the environmental exposure to standard field operations without actually using the filter to take a sample. The field blank is returned along with the regular filters for analysis.

The suggested frequency for the field blanks is 12-18 blanks in a year for a monitor operating at a 1 in 3 day schedule and for a monitor operating every day would have 36 to 54 blanks. The schedule of field blanks will be such that at least one blank will be weighed during each post sampling session. The pre and post sampling weights will be recorded in the QC lab data form or equivalent database. If the weight change exceeds 30 µg, contamination during transportation or at the sampling site may be occurring. Corrective steps must be taken to prevent this from happening again.

#### **5.2.6 Receipt of Sampled Filters:**

Upon receipt of the sample from the field, the sample custodian should follow these steps:

- 1) Verify that the temperature of the cooler's interior was maintained at or below 4°C from the time of shipment until receipt at the laboratory. Remove the filter cassette from its protective container and examine the container. If debris is found in the protective container after the filter has been removed, record that the sample has been flagged as questionable.
- 2) Examine the field data sheet and determine whether all data needed to verify sample validity and to calculate mass concentration are provided. Void the sample if data are missing or unobtainable from a field operator or if a sampler malfunction is evident.
- 3) Match the filter identification number with the correct Field Data Sheet. Remove the filter from the filter cassette and transfer the filter to a filter-handling container labeled with the corresponding filter number. The filter will be handled with clean, smooth nonmetal forceps and inspected for any damage that may have occurred during sampling. If damaged, note the sample has been flagged as questionable.
- 4) Transfer the filter to its bar-code labeled Petrislide dish then to the conditioning chamber and allow the filter to condition for at least 24 hours.

#### **5.2.7 Storage of Exposed filters**

If the post sampling weighing session is not scheduled immediately the filters will be stored in a refrigerator. After the filters have been weighed they will be returned to the refrigerator.

### **5.2.8 Filter Conditioning Procedure**

Filters must be conditioned prior to post-weighing. The exposed filters will be conditioned similar to an unexposed filter.

### **5.2.9 Post Sampling Filter Weighing (Gross Weight)**

The following steps should be followed during post sampling filter weighing.

- 1) Place the defect-free filter(s) in a conditioning environment and allow them to be equilibrated for a minimum 24 hours.
- 2) The post-sampling conditioning and weighing shall be completed within 240 hours (10 days) after the end of the sample period. However, if the filter is maintained at 4°C or less during the entire time between retrieval from the sampler and the start of the conditioning, the weighing shall be completed within 30 days of the end of the sample period.
- 3) Repeat the steps 1 through 4 described in the Initial Weighing Procedure Section.
- 4) At least one lab blank should be weighed during each weighing session. If the pre- and post sampling weights for the lab blanks disagree by more than 15 µg, repeat the measurements. If the pre and post sampling weights for the field blanks disagree by more than 30µg, repeat the measurements. If the two measurements still disagree, troubleshoot and take appropriate corrective step.
- 5) One routine filter should be reweighed at the end each post weighing session. Record this replicate measurement. If this replicate measurement differs from the original weight by more than 15 µg, reweigh the filter. If the measurement still disagrees, trouble shoot and take appropriate corrective action, such as reweighing all or some of the previously weighed filters, re-weighing the working standards or servicing the microbalance.

### **5.2.10 Filter Voiding Criteria and Procedures**

Each filter will be inspected for damage. If the damage on a filter causes a negative net weight, the filter will be voided. Filters will also be voided if during the weighing process the filter integrity is compromised; the filter is dropped, damaged or contaminated.

### **5.2.11 Internal QC**

During the filter weighing session, the following QC checks are recommended. Record QC data, including the actual and measured weights, the date and the operator's initials, on the internal Quality Control Log sheet, laboratory log book or database.

- 1) Zero and Calibration Checks - After each weighing, the operator will re-zero the balance. The calibration of the balance must be checked every 10 filters. A set of standard Class-S Weights (these weights may be the same set used for the initial "standard weight" check) should be used at levels bracketing the filter weights. These weights must also agree within ±0.5 mg. Larger discrepancies should be corrected immediately. When calibration checks exceed acceptable limits, all previously weighed filters must be rechecked.

- 2) Tare and Gross Weight Checks - On each day of operation, the operator should reweigh 5 to 10% of the exposed per batch. All the unexposed filters will be re-weighed. Weights of clean filters should be within  $\pm 15 \mu\text{g}$  of original values; if not, troubleshooting and re-weighing are in order. However, if the difference exceeds  $\pm 15 \mu\text{g}$ , the laboratory QC supervisor should investigate immediately.
- 3) QC Officer Duties - The QC officer should keep a bound laboratory logbook or database. These logbooks or database should contain all QC data, including balance calibration and maintenance information, internal routine QC checks, and independent audits.

#### ***5.2.12 Calculation of PM<sub>2.5</sub> Net Filter Loading***

The gross weight minus the tare weight of a PM<sub>2.5</sub> filter is the net weight of PM<sub>2.5</sub> for that filter. Each calculation of this process must be independently validated. Section 6 presents information regarding the calculation of PM<sub>2.5</sub> mass concentration.

**Table 5-1 Internal Quality Control Log Sheet**

<b>Balance ID Number</b> E110110										
<b>Balance Operator</b> S. Davis							<b>Quality Control Supervisor</b> C. Minish			
Date	Standard Weight Checks		Zero Check (±3 mg)		Calibration Check (±3 mg)		Tare and Gross Weight Checks			
	Original Value	Observed Value	Original Value	Observed Value	Original Value	Observed Value	Filter ID	Original Value	Observed Value	T/G <sup>a</sup>
9/30	100.000	99.999	0.000	0.000	100.000	99.999	99123546	140.740	140.730	T
9/30	200.000	199.999			200.000	199.997	99234701	141.707	141.717	G

<sup>a</sup> Tare or Gross Measurement

## 6 CALCULATIONS, VALIDATIONS, AND REPORTING OF PM<sub>2.5</sub> DATA

This section discusses calculations, validations and reporting of PM<sub>2.5</sub> data.

### 6.1 Calculations

#### 6.1.1 PM<sub>2.5</sub> Concentration

- 1) Calculate the total volume of air sampled:

$$V = Q_a \times t \times 10^{-3}$$

where:

$V$  = total volume of air sampled, m<sup>3</sup>;

$Q_a$  = average sampler flow rate, l/minute;

$t$  = total elapsed sampling time, minutes; and

$10^{-3}$  = Conversion factor, m<sup>3</sup>/L

- 2) Calculate total PM<sub>2.5</sub> mass concentration in µg/m<sup>3</sup>:

$$PM_{2.5} = \frac{(M_{gross} - M_{tare})}{V} \times 10^3$$

Where:

$PM_{2.5}$  = PM<sub>2.5</sub> mass concentration, µg/m<sup>3</sup>

$M_{gross}$  = gross (final) weight of filter, mg;

$M_{tare}$  = tare (initial) weight of filter, mg;

$V$  = total sample volume, m<sup>3</sup>; and

$10^3$  = conversion factor, µg/mg

### 6.2 Calculation Validation

Data that are needed to compute the mass concentration of PM<sub>2.5</sub> originate from two main sources: field operations and laboratory operations. Data must be validated to ensure that all reported PM<sub>2.5</sub> measurements are accurate relative to the overall scope of the quality assurance program. When the final mass concentration of PM<sub>2.5</sub> in a sample has been computed, the validation procedure not only will check on these computations, but also will aid in the flagging of questionable mass concentrations (i.e., extremely high or low values). Therefore, should a mass concentration approach the primary or secondary ambient air quality standard, this validation procedure will provide checks for all preliminary field and laboratory operations. The steps of the calculation validation procedure are as follows:

- 1) Gather the following data for each sample.
  - Total sampling time (minutes)
  - Average actual volumetric flow rate,  $Q_a$  (l/minute)
  - Tare and gross weights,  $W_t$  and  $W_g$ , of the PM<sub>2.5</sub> filter (mg)

- 2) Recalculate the total mass concentration of PM<sub>2.5</sub> for 7 samples per 100 (minimum of 4 per lot). These suggested frequencies may be adjusted based on accumulated experience and level of data quality. Decrease the frequency if experience indicates that data are of good quality, or increase it if data are of marginal or poor quality.
- 3) Compare each validated PM<sub>2.5</sub> concentration with the originally reported value. Correct any errors that are found, initial them and indicate the date of correction. If a high percentage of errors is found, check additional calculated values. If consistent errors are found, check all values in the block of data and investigate and correct the cause.
- 4) Scan all total mass concentration values; note those that appear excessively high or low and investigate. Repeat Steps 2 and 3 for those samples.
- 5) If all mass concentration computations appear correct and questionably high or low values still exist, review all raw data (i.e., sample time, average actual volumetric flow rate) for completeness and correctness.

### **6.3 Final Data Validation**

Data that has been reviewed by the Quality Assurance Unit and found to satisfy the requirements of this procedure and the criteria defined in the Washington State Department of Ecology Air Monitoring Quality Assurance Plan will be certified as valid.

### **6.4 Data Reporting**

Data is coded into telemetry system database from the laboratory reports. After the data is logged and edited the Data Management Unit will prepare quarterly and annual summary reports and transmit the data to EPA.

## **7 MAINTENANCE PROCEDURES**

This section presents the regular maintenance schedule that allows the monitoring network to operate for longer periods of time without system failure. The operator may find that increases of the routine maintenance frequencies are necessary due to the operational demands on the samplers. All maintenance activities are to be documented in the sampler logbook. Table 7.1 is a summary of required maintenance procedures and frequencies.

### **7.1 Supplies And Tools Recommended For Maintenance:**

- 1) Ammonia based general purpose cleaner
- 2) Cotton swabs
- 3) Small soft-bristle brush
- 4) Paper towels
- 5) Distilled water
- 6) Silicone-based stopcock grease

- 7) Small screwdriver
- 8) Small crescent wrench
- 9) Pocket knife

## **7.2 Spare Parts**

- 1) Spare gaskets
- 2) O-rings
- 3) Batteries
- 4) Anything else that might wear out

## **7.3 Exchanging Particle Trap Filters**

The particle trap filters are located behind the filter exchange assembly. Perform the procedure below to exchange the particle trap filters

- 1) Turn off the sampler.
- 2) Locate the bowl-style filter behind the filter exchange assembly. Remove the filter bowl by unscrewing it from the filter manifold.
- 3) Carefully remove the filter stand by unscrewing it from the filter. The O-ring usually remains in the filter manifold.
- 4) Remove the gasket and top disk from the filter stand. The gasket might sometimes remain inside the filter manifold.
- 5) Remove the filter element from the filter stand and install a new element.
- 6) Install the top disk and gasket if necessary into the filter stand.
- 7) Install the filter stand into the filter manifold. Install the O-ring into the filter manifold, if necessary.
- 8) Install the filter bowl into the filter manifold.
- 9) Turn on the sampler and perform a system leak check.

## **7.4 Testing And Exchanging Batteries**

The three alkaline AA batteries in the electronics provide backup power for internal data storage and the clock/calendar. The expected lifetime of the batteries in the instrument is one year.

**NOTE:** Always wear appropriate anti-static devices when working with the system electronics.

Follow the steps to ascertain if the batteries need replacing, and to exchange if necessary

- 1) Remove the three screws securing the Pump Compartment Cover, slide the cover up and remove.
- 2) Open the electronics compartment of the sampling unit and locate the batteries.
- 3) Check whether the batteries need replacing by measuring the voltage across the test point labeled “BATT” (red) on the interface board and the ground test point labeled “188\_PGND”. If the measured voltage is less than 4.2 VDC, the batteries need replacing. Skip to step 6 if the voltage is acceptable.
- 4) Remove the clip that holds batteries in their mounting and pull the old batteries out and replace them with 3 new ones, noting the proper polarity. Perform this exchange within an elapsed time of five minutes to avoid the loss of data stored in the battery-backed RAM.
- 5) Reinstall the clips to hold the batteries in position. Test for a voltage of 4.2 VDC as in step 4.
- 6) Close the electronics compartment of the sampling unit.

## **7.5 Maintenance R&P First Stage And Inlet PM<sub>10</sub> And Associated Sub-assemblies**

### ***7.5.1 Cleaning The R&P First Stage and PM<sub>10</sub> Inlets***

A cleaning and maintenance of the inlet, involves its removal, cleaning and an O-ring check. Although most of the contamination in the inlet is found on the collector plate, the entire inlet must be serviced at least monthly. The following describes the procedure for the cleaning of the inlet.

### ***7.5.2 Removing And Disassembling The Inlet***

- 1) To remove the inlet, gently lift the complete inlet upward off the 1-1/4” OD sample tube.
- 2) Disassemble the upper and lower inlet halves by unscrewing counter-clockwise the top acceleration assembly from the lower collector assembly.

### ***7.5.3 Maintenance Of The Top Acceleration Assembly***

- 1) Mark the top plate deflector cone and lower plate with a pencil scribe to facilitate proper orientation for easier reassembly after cleaning and maintenance.
- 2) Using a Philips-blade screwdriver, remove the four pan head screws from the top of the top plate, and lift the top plate off the four threaded spacer standoffs and set aside.
- 3) Inspect the insect screen for contamination and clean by lifting the screen off the lower plate rain deflector and brush or rinse with water until clean. Dry and reinstall.

- 4) Using a general purpose cleaner and paper towel, clean the top plate deflector cone and internal wall surface of the acceleration assembly.
- 5) Inspect the large diameter impactor nozzle O-ring for wear. Replace, if necessary, or using a light coating of silicone grease, apply a thin film on the O-ring itself and a light coating on the aluminum threads of the acceleration assembly.
- 6) After reinstalling the bug screen, align the top plate markings with the lower plate markings. The four holes in the top plate should align with the four spacer standoffs. Insert and tighten securely the four pan-head screws.

#### **7.5.4 Maintenance Of The Lower Collector Assembly**

- 1) Using a general-purpose cleaner with a paper towel, clean the collector assembly walls and three vent tubes. A cotton swab may be necessary to clean these vent tubes. Likewise, clean the bottom side of the collector assembly.
- 2) Using a cotton swab, also clean the weep hole in the collector plate where the moisture runs out to the moisture trap. Remove the rain jar and clean. Inspect the brass nipple fitting to ensure tightness and non-blockage. When reinstalling the rain jar, place a light coating of silicone grease on the gasket inside the cap of the rain jar. This will ensure a leak-free fit.
- 3) Inspect the two inlet-to-inlet tube sealing O-rings for wear. Replace, if necessary. Use a light coating of silicone grease on these O-rings to ensure that a seal is made when reinstalled on the 1-1/4" OD sample tube.

#### **7.5.5 Reassembly And Reinstallation Of Inlet**

- 1) Reassemble the top and bottom inlet assemblies until the threads tighten. Hand-tighten only.
- 2) Carefully place the inlet back on top of the 1 1/4" OD sample tube. Take care not to damage the internal O-rings.

### **7.6 Maintenance Of The WINS Impactor**

The procedure below describes the removal, cleaning, and reinstallation of the WINS impactor. The cleaning of the WINS impactor should be performed within a laboratory or workroom environment.

#### **7.6.1 Removal of the WINS impactor**

- 1) If the sampler is currently in the Wait, Sampling, or Done Operating Modes press <RUN/STOP> and select Audit to enter the Audit Operating Mode. This suspends normal system operations for the exchange of the WINS impactor.

**NOTE:** No action is required in this step if the sampler is in the Stop or Error Operating Modes.

- 2) Unlatch and open the top cover of the sampler with the down tube and first-stage inlet attached to gain access to the WINS impactor.
- 3) Lift the WINS impactor out of the upper part of the sampler enclosure. The WINS impactor is connected on its topside to an adapter that makes contact with the external down tube. Separate the WINS impactor from the adapter.

### **7.6.2 *Cleaning the WINS impactor***

- 1) Unscrew the middle section of the WINS impactor to separate the top piece from the bottom.
- 2) Remove the impactor assembly from the bottom section of the impactor.
- 3) With a dry paper towel, wipe off the inside surfaces of the impactor. A general-purpose cleaner can be used if necessary.
- 4) Inspect the O-rings in the top and bottom sections of the impactor for damage and replace if necessary. Place a thin coating of O-ring lubricant onto the O-rings if necessary.
- 5) Remove the top of the impactor assembly by lifting upward.
- 6) Remove the filter and clean the top and bottom of the impactor assembly using a dry paper towel. A general-purpose cleaner can be used if necessary.
- 7) Inspect the O-ring in the top section of the impactor assembly for damage and replace if necessary. Place a thin coating of O-ring lubricant onto the O-ring, if necessary.
- 8) Place a new 37-mm borosilicate glass fiber filter onto the bottom of the impactor assembly.
- 9) Place 42 to 44 drops of impactor oil onto the filter.
- 10) Place the top onto the bottom of the impactor assembly.
- 11) Place the impactor assembly into the bottom section of the impactor.
- 12) Screw the top of the impactor back onto the bottom section. Ensure that the WINS impactor remains in the upright orientation so that the oil in the impactor assembly does not spill.

### **7.7 *Cleaning Air Intake Filters***

The two filters – one in the filter compartment and one in the pump compartment, should be cleaned at least every six months and more frequently in highly contaminated areas.

- 1) Locate the two air-intake fans. Each of these has an associated air intake filter.
- 2) Snap off the covers enclosing the air intake filters.

- 3) Take out the filters and clean them with a brush or wash them with a mild soap solution and water.
- 4) If the filters were washed in the liquid solution, shake the filters and allow them to dry.
- 5) Reinstall the filters in their holders and remount the covers.

#### **7.8 Inspect “V” Seals**

- 1) Ensure the instrument is in the STOP mode.
- 2) Enter Service Mode
- 3) Set the pointer to “Manual Motion Tests” on the Service Menu and press <F4:FiltChg> to go to the Filter Exchange Screen.
- 4) On the filter Exchange Screen, turn on the pump (labeled Pump), turn on the pressure vent valve (labeled “Pressure”) and turn on the lift/push valve (labeled “LiftPush”). This will cause the lift/push cylinder (the middle cylinder on the filter exchange assembly) to retract and will help ease disassembly.
- 5) Unlatch and open the top cover of the Partisol-Plus Sampler with the down tube and first-stage inlet end attached to gain access to the WINS impactor.
- 6) Lift the WINS impactor out of the upper part of the sampler enclosure and locate the down tube mount on the top cover.
- 7) While supporting the ring on the underside of the top cover, remove the four screws that secure the down tube mount to the top cover. Remove the down tube mount and ring.
- 8) Locate the down tube mount “V” seal. Examine seal for drying and/or cracking. Replace, if necessary.
- 9) Replace the down tube mount and ring onto the top cover ensuring that the side of the ring with the chamber is facing down (towards WINS impactor and the inside of the enclosure).
- 10) Locate the top head mounting plate.
- 11) Remove the 4 thumbscrews that secure the top head mounting plate to the filter exchange assembly. Lift the plate and remove from the enclosure.
- 12) Locate the two “V” Seals now exposed. The top seal is located in the top head. The bottom seal is located in the now exposed section of the filter exchange assembly. Examine both seals for drying/cracking. Replace, if necessary.
- 13) Locate the exit cylinder. Remove the three screws that secure the exit cylinder base to the filter exchange assembly. Remove assembly from enclosure.
- 14) Locate the exit cylinder “V” seal and examine the seal for drying/cracking. Replace, if necessary.

- 15) Place the exit cylinder base in its proper position on the filter exchange assemble and secure using the three screws.
- 16) Replace the top head mounting plate and secure using the four thumbscrews.
- 17) Replace the WINS impactor and close the top cover.
- 18) On the Filter Exchange Screen, turn off the lift/push valve (labeled "LiftPush", turn off the pressure vent valve (labeled "Pressure") and turn off the pump (labeled "Pump).
- 19) Perform an external leak test and an internal leak test according to the procedure outlined in this manual.
- 20) Resume normal operation.

## **7.9 Other Maintenance**

Wipe down the interior of the sampler's case to remove bugs, dirt, and/or water deposits that may have collected inside the case. This may be required more frequently during summer months. Inspect the cooling air intake filter during the summer months and clean if necessary.

## **7.10 Software Update**

The operator must update software to the latest version of software by the deadline approved by the air monitoring coordinator at Dept. of Ecology.

**Table 7-1 Routine Maintenance Activities**

EQUIPMENT	FREQUENCY	ACTION
WINS Impactor	Every 5 sampling days	Replace with clean WINS impactor
Water Collector Jar	Every 5 sampling days	Clean
Tubing and fittings	Every 5 sampling days	Replace as necessary
Upper and Lower Collector Assembly	Monthly	Clean
Inlet O-rings	Monthly	Inspect, replace if damaged
Inlet O-rings	Quarterly	Remove, inspect, and lightly coat with vacuum grease
Sampler down tube	Quarterly	Clean
Down tube water seal gasket	Quarterly	Inspect and replace if necessary
WINS impactor gasket and O-rings	Quarterly	Inspect, lubricate and replace if necessary
Air intake and fan	Quarterly	Clean
Vacuum motor	As needed	Replace if needed
Power lines	Inspect on sample-recovery days	Replace as necessary

## **8 DATA FORMS**

Blank data forms are provided on the following pages for the convenience of the manual user.

## QC Check

## Ambient

## Pressure Check

## Flow Check

## Leak Check

$$\text{QC \% Difference} = \left[ \frac{Ind - Act}{Act} \right] \times 100$$



**Table 8-3 PM<sub>2.5</sub> Sampler Annual Performance and Maintenance Check Sheet**

	Frequency	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Acceptance Criteria
One Point Flow Rate Verification	1/4 Weeks													± 4% of the Transfer Standard
Flow Rate multi-point Verification	1/Year Or if One Point Failure													± 4% of the Transfer Standard
Flow Rate Calibration	If Multi-Point Failure													± 4% of the Transfer Standard
Temperature Multi-point Verification	1/Year													± 2°C of Standard
Temperature Calibration	If Multi-Point Failure													± 2°C of Standard
Pressure Verification	1/4 Weeks													± 10 mm Hg.
Pressure Calibration	1/Year													± 10 mm Hg.
Clock/timer Verification	1/4 Weeks													1 min/month
Disassemble, Inspect and Clean Sample Inlet	1/4 Weeks													
Clean Interior of Sample Case	1/4 Weeks													

**Table 8-4 PM<sub>2.5</sub> Sampler Quarterly Performance and Maintenance Check Sheet**

External Leak Check	Every 5 Sampling Events																		80 ml/min
Internal Leak Check	Every 5 Sampling Events																		80 ml/min
One-point Temperature Verification	1/4 Weeks																		± 4°C of Standard
Water Collector Bottle Inspection	Every 5 Sampling Events																		
Impactor Well Cleaning and Oiling	Every 5 Sampling Events																		

**Table 8-5 Internal Quality Control Log Sheet**

<b>Balance ID Number</b>										
<b>Balance Operator</b>							<b>Quality Control Supervisor</b>			
<b>Date</b>	<b>Standard Weight Checks</b>		<b>Zero Check (±3 mg)</b>		<b>Calibration Check (±3 mg)</b>		<b>Tare and Gross Weight Checks</b>			
	<b>Original Value</b>	<b>Observed Value</b>	<b>Original Value</b>	<b>Observed Value</b>	<b>Original Value</b>	<b>Observed Value</b>	<b>Filter ID</b>	<b>Original Value</b>	<b>Observed Value</b>	<b>T/G<sup>a</sup></b>

**Table 8-6 Initial Calibration Form**

**Partisol-Plus Model 2025 Sequential Air Sampler Calibration Sheet**

Sampler Data	Impactor Data
Serial Number: 2025A2 _____	Serial Number: 200FA4 _____

**Instrument Calibration Constant Values:**

Screen	Assignment	Offset	Span
Sensor Calibration	Amb Temp:  Amb Pres:		
Filter Temp Calibration	Filter:		
Filter Compartment Calibration	Filter Comp:		
Flow Calibration	Flow Calib:		

Software Version:	_____	Software Update	_____
Signature	_____	Date	_____